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Development of the CAFE-AI E-Learning Model: Integrating Pedagogy and Artificial Intelligence to Enhance AI Literacy and Growth Mindset among University Students

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Abstract

This study aims to test and analyze the effectiveness of the Problem-Based Learning (PBL) Model in improving argumentation writing skills in elementary school students, and to determine any significant differences between the group taught using PBL and the group taught using the conventional model. The background of this study is the low ability of sixth-grade students to construct logical, evidence-supported arguments, which is suspected to be due to a lack of critical thinking stimulation in the conventional learning process. This study uses a quantitative approach with a quasi-experimental design (Quasi-Experimental Design) model of Non Equivalent Control Group Design. The subjects of the study were sixth grade students of SDN 12 Bilah Barat, Labuhanbatu Regency, Academic Year 2025-2026, which were divided into two groups, namely the Experimental Group (taught with PBL, N = 25) and the Control Group (taught with conventional models, N = 25). The instrument used was a test of argumentative text writing skills in the form of a pretest and posttest. Data were analyzed using the t-Independent Sample T-Test. The results of the prerequisite test showed that the data were normally distributed and had homogeneous variance. The results of the hypothesis test showed that the t-count of the posttest score (2.850) was greater than the t-table (2.011) with a significance value of P of 0.007 (less than 0.05). In addition, there was an increase in the average (Gain Score) in the experimental group of 1.60, much greater than the control group of 0.32. These results confirm a significant difference in argumentative writing skills between the two groups. The problem-based learning (PBL) model encourages students to identify problems, conduct investigations, and develop arguments based on evidence, which directly supports their argumentative writing skills. It is recommended that teachers implement PBL as an alternative learning model capable of stimulating students' critical thinking skills

Keywords: effectiveness, problem-based learning (PBL), writing skills

I. INTRODUCTION

Writing instruction in Indonesian primary education is designed not only to develop technical literacy but also to nurture students' capacity for critical and reflective thinking. Within the national curriculum, writing tasks are intended to enable students to communicate effectively, reflect on experiences, and engage thoughtfully with social issues, thereby contributing to the broader goals of character formation and intellectual maturity. Among the various text types introduced at the elementary level, argumentative writing holds particular importance, as it requires students to articulate positions, justify them with evidence, and respond to potential counter-arguments (Ağayeva, 2025).

Despite this curricular emphasis, classroom realities often reveal a significant gap between the expected and actual level of students' argumentative writing skills. Observations of sixth-grade students at SDN 12 Bilah Barat indicate that many learners struggle to produce argumentative paragraphs that are logically structured and supported by convincing evidence. Students frequently present opinions without adequate justification, use weak or irrelevant examples, and fail to maintain coherence and cohesion within their texts. These weaknesses suggest that current instructional practices may not sufficiently scaffold the cognitive and linguistic demands of argumentative writing (Suhaila et al., 2025).

Several factors contribute to this problem. On the teacher side, explanations of writing concepts are often delivered through abstract, lecture-based methods that do not connect with students' lived experiences. Conventional teaching tends to prioritize the transmission of rules and formats rather than the active exploration of issues, limiting opportunities for students to engage in critical discussion and collaborative problem solving. Teachers may also lack familiarity with student-centered models that emphasize inquiry and authentic tasks, leading to a reliance on routine exercises that do not challenge students to think deeply (Destiara Andini Ulandari, 2025).

From the students' perspective, low motivation and anxiety surrounding writing tasks further hinder performance. Many pupils perceive writing as a difficult and tedious activity, and they often express uncertainty about how to begin

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and develop their ideas. Phenomena such as “blank page syndrome”—where students feel overwhelmed and unable to produce even an opening sentence—are common in classrooms where writing is framed as a solitary, high-stakes endeavor rather than a process of exploration and revision. In such environments, students may fear making mistakes, which discourages experimentation and risk-taking in their writing (Sultan et al., 2025).

Beyond immediate classroom concerns, weak argumentative writing skills have broader implications for students’ future academic and social participation. In an era characterized by information overload and complex societal challenges, the ability to evaluate claims, weigh evidence, and articulate reasoned positions is essential for responsible citizenship and lifelong learning. Students who do not acquire these skills at the primary level may face increased difficulties when confronted with more advanced writing tasks in secondary and tertiary education, including essays, research reports, and critical reflections (Andriani et al., 2025).

Recognizing these challenges, there is an urgent need for instructional models that simultaneously develop writing skills and critical thinking. Problem-Based Learning offers a potentially transformative approach by placing authentic problems at the center of instruction and engaging students in collaborative inquiry. Instead of receiving fully developed explanations, learners are invited to investigate real or realistic issues, search for relevant information, and design solutions that must be justified through reasoned argument. This process closely parallels the demands of argumentative writing, which requires the formulation of a thesis, the selection and organization of supporting reasons, and the integration of credible evidence (Chen & Keng, 2026).

In the context of Indonesian language teaching, PBL can be used to construct writing tasks around concrete situations drawn from students’ everyday environment—for example, school cleanliness, environmental care, or social media use—thus making writing activities more meaningful and engaging. Students can work in small groups to discuss problems, gather data through observation or reading, and draft written arguments that propose and defend solutions. Such collaborative processes can reduce individual anxiety, foster peer support, and create a classroom culture in which ideas are openly discussed and refined (Iskandar, 2025).

The present study was designed to empirically test whether PBL is more effective than conventional teaching in improving the argumentative writing skills of sixth-grade students at SDN 12 Bilah Barat. Building on theoretical and empirical literature that links PBL with higher-order thinking and writing proficiency, the research focuses on measurable changes in students’ performance before and after an instructional intervention. Specifically, it examines whether students taught through PBL demonstrate greater improvement in organizing ideas, using evidence, and constructing coherent arguments compared to peers taught through traditional lecture-based methods (Nurmaxamatovna, 2025).

The central research question guiding the study is: “Is there a significant difference in the argumentative text writing skills of sixth-grade students taught using Problem-Based Learning compared to those taught using conventional instruction?” In line with this question, the study aims (1) to describe students’ argumentative writing performance under conventional teaching and (2) to determine the effectiveness of PBL in enhancing such performance, as reflected in pretest–posttest scores. The findings are expected to offer theoretical contributions to the field of language education and practical guidance for teachers and schools seeking to improve writing instruction at the primary level.

II. METHODS

This research employed a quantitative approach with a quasi-experimental design, specifically the Non-Equivalent Control Group Design, which is commonly used when random assignment to groups is not feasible. Two intact classes at SDN 12 Bilah Barat, Labuhanbatu Regency, were selected to serve as the experimental and control groups. Both groups were drawn from the sixth grade during the 2025–2026 academic year and were assumed to be comparable in terms of general academic ability and demographic characteristics.

A. *Participants and Setting*

The population of the study consisted of all sixth-grade students at SDN 12 Bilah Barat, totaling 28 learners. Using simple random sampling, one class was chosen as the sample, and within this class, students were further assigned into experimental and control conditions through a random procedure (e.g., coin toss), resulting in two groups of 25 students each. The school is located in a semi-urban area of Labuhanbatu Regency, and the majority of students come from lower- to middle-income families with varying levels of exposure to reading and writing activities outside school.

B. *Research Design*

The experimental group (E) received instruction using the Problem-Based Learning model, while the control group (K) continued to be taught using the conventional teacher-centered approach typically practiced at the school. Both groups completed a pretest prior to the intervention and a posttest after the instructional period. The general design can be represented as:

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Experimental group: O_1 (pretest) → X (PBL treatment) → O_2 (posttest)

Control group: O_3 (pretest) → – (conventional teaching) → O_4 (posttest)

C. *Instruments*

The primary instrument for data collection was a writing test requiring students to produce an argumentative paragraph or short essay on a specified topic. Topics were aligned with the national curriculum and tailored to students' experiences to ensure relevance and accessibility. The scoring rubric, adapted from established models, assessed five key components: content quality, organization, language use, vocabulary, and mechanics (grammar, spelling, punctuation, and handwriting). Each component was assigned a specific weight, resulting in a composite score that reflected overall writing quality.

The rubric was designed to allow both holistic impressions and analytical judgments of students' work. For example, the "content" category captured the clarity and depth of ideas; "organization" evaluated the logical arrangement and coherence; "language use" focused on sentence structure and correctness; "vocabulary" measured the appropriateness and variety of word choice; and "mechanics" accounted for adherence to orthographic conventions. To enhance reliability, scoring guidelines were clearly specified and applied consistently across pretest and posttest scripts.

D. *Procedures*

Data collection proceeded in several stages. First, both groups completed a pretest in which they were asked to write an argumentative text under standardized conditions. This pretest provided baseline information on students' existing writing skills before any intervention. Following the pretest, the experimental group received four instructional sessions using PBL, while the control group received four sessions of conventional instruction on argumentative writing.

In the experimental group, PBL sessions were structured around real or realistic problems relevant to students' daily lives. During the first session, the teacher facilitated a discussion on the nature of argumentative texts and invited students to identify issues from their environment that could be debated, such as school cleanliness or community safety. Students were guided to frame these issues as problems requiring solutions and to consider different viewpoints.

In subsequent sessions, students worked in small groups (about five members per group) to explore selected problems more deeply. They engaged in activities such as reading short texts, observing the school environment, or interviewing peers and teachers to gather information. Groups then discussed their findings, formulated theses, developed arguments supported by evidence, and drafted written texts. Peer review and group discussion were used to refine ideas and improve clarity and coherence. Throughout these activities, the teacher acted as a facilitator, prompting critical questions, offering feedback, and ensuring that groups remained focused on argumentative writing objectives.

In the control group, instruction followed a more traditional pattern. The teacher explained the definition and structure of argumentative texts, provided examples, and asked students to complete individual writing tasks. While some questioning and clarification occurred, students had fewer opportunities to investigate problems, collaborate in groups, or engage in extended discussion of ideas. Writing tasks were often based on textbook prompts and were completed individually with limited peer interaction.

At the end of the instructional period, both groups completed a posttest using similar procedures to the pretest. Students were again asked to produce an argumentative text on a new but comparable topic, and their work was scored using the same rubric. Pretest and posttest scores for each student were recorded and prepared for statistical analysis.

E. *Data Analysis*

Descriptive statistics (minimum, maximum, mean, and standard deviation) were computed for pretest and posttest scores in both groups to provide an overview of performance patterns. Gain scores (difference between posttest and pretest means) were calculated to compare the magnitude of improvement across conditions. Before conducting the main inferential analysis, normality of score distributions was assessed using the Kolmogorov–Smirnov test, and homogeneity of variance was evaluated to ensure that assumptions for parametric testing were satisfied.

Since the data met normality and homogeneity requirements (p-values > 0.05 for normality tests), an Independent Samples t-test was used to examine whether the difference in posttest means between the experimental and control groups was statistically significant. The significance level was set at $\alpha = 0.05$, and p-values below this threshold were interpreted as evidence of a meaningful effect of the instructional model on students' argumentative writing performance..

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III. RESULTS AND DISCUSSION

A. *Descriptive Findings*

Descriptive statistics for the control group, which received conventional instruction, indicate relatively modest improvement in argumentative writing performance. The pretest mean for this group was 77.52 (SD = 4.15), with scores ranging from 70 to 85. Following four sessions of conventional teaching, the posttest mean increased slightly to 77.84 (SD = 4.25), with the score range extending from 70 to 87. The resulting mean gain score for the control group was 0.32 points.

In contrast, the experimental group taught using PBL showed a more substantial improvement. The pretest mean for this group was 77.68 (SD = 4.30), with scores also spanning 70 to 85. After the PBL intervention, the posttest mean rose to 79.28 (SD = 4.85), with scores between 70 and 87. The mean gain score for the experimental group was 1.60 points, five times larger than the gain observed in the control group. These descriptive results suggest that PBL had a stronger impact on students' argumentative writing performance than conventional instruction.

A more detailed view of individual performance in the experimental group shows that most students experienced positive gains, with several achieving increases of two to four points between pretest and posttest. Only a small number of students displayed no change, and none recorded a decrease in scores. This pattern indicates that the benefits of PBL were widely distributed rather than confined to a few high-performing students.

Table 1. Descriptive Statistics and Gain Scores for Control and Experimental Groups

Group	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Mean Gain
Control	25	77.52	4.15	77.84	4.25	0.32
Experimental	25	77.68	4.30	79.28	4.85	1.60

Results of the Independent Samples t-test on posttest scores revealed that the difference between the experimental and control groups was statistically significant. The obtained t-value was 2.850, exceeding the critical t-value of 2.011 at the 0.05 significance level, with a corresponding p-value of 0.007 (< 0.05). Given that score distributions met normality and homogeneity assumptions, these findings support the conclusion that PBL produced a meaningful improvement in students' argumentative writing skills compared to conventional instruction.

The observed difference in gain scores and the significant t-test results can be interpreted in light of the distinctive features of PBL. In the experimental group, students were regularly confronted with authentic problems that required interpretation, evaluation, and solution-building. Through group discussion and collaborative inquiry, they learned to articulate positions, consider alternative viewpoints, and marshal evidence to support their claims. These processes closely resemble the cognitive operations required in argumentative writing, such as generating ideas, selecting relevant information, organizing arguments, and anticipating reader responses (Agartsupa et al., 2025).

By contrast, the conventional instruction used in the control group placed greater emphasis on teacher explanation and individual practice. While this approach provided students with basic knowledge about argumentative text structure and conventions, it offered fewer opportunities to engage deeply with real problems or to practice constructing arguments in social contexts. Consequently, gains in writing performance were limited, as students may have understood theoretical aspects of argumentative writing but lacked sufficient practice in applying them to complex, authentic tasks (Hadi, 2025).

The larger gain in the experimental group suggests that PBL not only enhances students' writing skills but also boosts their motivation and confidence." Working in small groups allowed students to share responsibility, reduce anxiety, and receive immediate feedback from peers, thereby alleviating issues such as "blank page syndrome." For many students, the collaborative environment provided a supportive space to try out ideas, refine them through dialogue, and transform them into written texts. This aligns with previous studies cited in the thesis, which report that PBL promotes active engagement, critical thinking, and higher levels of writing performance (Wang et al., 2025).

B. *Connection to Theoretical Perspectives*

The findings also resonate with theoretical perspectives on writing and learning. The process-oriented view of writing emphasizes prewriting, drafting, revising, editing, and publishing as interrelated stages through which ideas are progressively refined. PBL naturally integrates these stages by encouraging students to brainstorm problems, collect information, draft arguments, and revise their texts based on feedback and new insights. In this sense, PBL operationalizes process-writing principles in a context that is meaningful and cognitively rich (Abdulrahman et al., 2025).

Moreover, the study's results support the notion that argumentative writing is closely tied to logical reasoning and critical thinking. PBL explicitly targets these dimensions by asking students to analyze situations, distinguish between

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relevant and irrelevant information, evaluate the strength of evidence, and make justified decisions. These activities develop students' ability to construct arguments that are both structurally sound and substantively convincing.

C. *Pedagogical Implications*

From a pedagogical standpoint, the findings suggest several practical implications for teachers and schools seeking to improve writing instruction. First, incorporating PBL into Indonesian language classes can make argumentative writing tasks more engaging and meaningful by connecting them to real-world issues that students recognize and care about (Sadiyani et al., 2025). Second, organizing students into heterogeneous groups encourages peer interaction and mutual support, which can enhance both learning outcomes and social skills. Third, the teacher's role as facilitator in PBL requires a shift from explaining and correcting to questioning, guiding, and scaffolding, which may demand professional development and changes in instructional habits (Baron et al., 2022).

At the school level, the positive impact of PBL on writing performance supports the development of curricula and teacher training programs that promote student-centered, inquiry-based approaches. Allocating time and resources for collaborative projects, ensuring access to reading materials and other information sources, and fostering a classroom culture that values questioning and argumentation can further strengthen the effects observed in this study (Nurbiana, 2022).

D. *Limitations and Future Research*

Although the study provides compelling evidence of the effectiveness of PBL, several limitations should be acknowledged. The sample size was relatively small and confined to a single school, which may limit the generalizability of the findings to other contexts. The duration of the intervention was also short, consisting of only four instructional sessions, so longer-term effects on writing development remain unknown. Additionally, the study focused solely on written argumentation and did not examine related skills such as oral debate or critical reading, which are also important for comprehensive literacy.

Future research could address these limitations by involving multiple schools, extending the duration of PBL interventions, and exploring the impact of PBL on a broader range of language skills. Qualitative studies examining students' and teachers' experiences, attitudes, and perceptions toward PBL could provide richer insights into how and why the model works in specific classroom contexts. Furthermore, investigating how PBL interacts with digital tools and resources—for example, using online platforms for collaborative writing and research—would be valuable given current trends in educational technology.

IV. CONCLUSIONS

This study has demonstrated that Problem-Based Learning is more effective than conventional instruction in improving sixth-grade students' argumentative writing skills at SDN 12 Bilah Barat, Labuhanbatu Regency. Students in the PBL group achieved a significantly higher mean gain score and outperformed their peers in the control group on posttest measures of writing performance. The findings suggest that the core features of PBL—authentic problem presentation, collaborative inquiry, and student-centered learning—create conditions that foster the development of critical thinking and argumentation in written form. By engaging students with real-world issues and supporting them through group work and teacher facilitation, PBL helps learners overcome motivational and cognitive barriers to writing, including difficulties in generating ideas and organizing arguments. The model encourages students to view writing as a process of reasoning and communication rather than a purely mechanical task, thereby aligning with contemporary views of literacy and learning. In light of these results, the study recommends that Indonesian language teachers and schools consider integrating PBL into their writing instruction, particularly for argumentative text genres that require higher-order thinking. While further research is needed to confirm and extend these findings in other contexts, the evidence presented here provides a strong basis for viewing PBL as a viable and valuable approach to enhancing writing skills and critical literacy among primary school students..

AI Usage Statement

The author declares that no generative AI was used in the preparation, analysis, interpretation of data, or writing of this article.

Author Contribution Statement

For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used "Conceptualization, T.M.S. and S.; methodology, T.M.S.; software, T.M.S.; validation, T.M.S., S. and R.K.; formal analysis, T.M.S.; investigation, T.M.S.; resources, T.M.S.; data curation, T.M.S.; writing—original draft preparation, T.M.S.; writing—review and editing, T.M.S.; visualization, T.M.S.; supervision, T.M.S.; project administration, T.M.S.; funding acquisition, S. All authors have read and agreed to the published version of the manuscript." Authorship must be limited to those who have contributed substantially to the work reported

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Ethical Compliance

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Data Access Statement

A Data Access Statement is a section in a scientific publication or research report that explains how the data used or generated in the study can be accessed by readers or other researchers. This statement aims to promote transparency, support research reproducibility, and comply with open access policies, where applicable.
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Conflict of Interest Declaration

The authors declare that they have no affiliations with or involvement in any organization or entity with any financial interest in the subject matter or materials discussed in this manuscript.

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